§5. Comparison of Impurity Poloidal Rotations in Recent Improved Modes in CHS

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Rotations and electrostatic potentials in plasmas with the neoclassical internal transport barrier (N-ITB)[1] were previously investigated in Higashiyama-site experiments [2]. In these operations in a low density (n_e~10^{12}cm^{-3}) and high temperature ($T_e(0)$ ~ 2-3keV) region achieved by applying the 53GHz 2nd harmonic electron cyclotron heating (B=0.9T), the strong positive radial electric fields of E_r~20kV/m were observed. This value is comparable to that of the negative radial electric fields in tokamak H-mode [3] and therefore their shear of ~100kV/m^2 was the most plausible candidate for mechanisms of the improved confinement. A quantitative theoretical calculation using a recently developed method was also done and the possibility of the strong positive radial electric fields is confirmed [4]. Fig.1 shows recent results of the charge exchange spectroscopy using fully ionized carbon ions (C^{6+}) in the N-ITB operations investigating the configuration dependence of this phenomenon. Since the poloidal rotation term is nearly equal to the radial electric field term in the impurity radial force balance equation in heliotron configurations [5], these poloidal rotation velocities of up to 20km/s in the direction of ion diamagnetic drifts indicate the radial electric field of E_r~20kV/m. These strength and direction are universally observed in various magnetic configurations with the vacuum magnetic axis positions of R_{ax}=92.1~97.4cm.

The edge transport barrier (ETB) [6] was found in a relatively high density (n_e~(2-4)×10^{13}cm^{-3}) and low temperature (T_e~300-400eV) regime with the high power neutral beam injection (NBI) (30-40kV, 800kW×2). This operating condition corresponds to the plateau collisionality regime defined in the neoclassical theory, and therefore a weak negative radial electric field is expected as observed in previous NBI heating experiments. Fig.2 shows the measured results in an ETB operation in the configuration with the magnetic axis position of R_{ax}=92.1cm. The magnetic field strength is B=0.9T. The poloidal rotation in the electron diamagnetic direction with the velocity of < 10km/s indicates weak negative radial fields of $|E_r|$ < 10kV/m. These values and the profile are typical ones in previous NBI heated plasmas [5]. In spite of the L→H transition that occurred at t≅60ms in these example shots, the poloidal rotation remains to be <10km/s before and after the transition.

This dependence of the radial electric fields on the collisionality observed in these recent contrastive two operational conditions also support the theoretically predicted tendency that has been confirmed in various types of helical devices. The next remaining theme may be the transition of the radial field in an intermediate collisionality regime. However, this conclusion by the measurement using fully ionized carbon relates to characteristics of the plasmas in the core regions of r/a≤0.9. At the edge region of 0.9≤r/a≤1, the large density gradient in ETB may cause changes of E_r or some other parameters, therefore the Langmuir probe measurement is in progress [7].

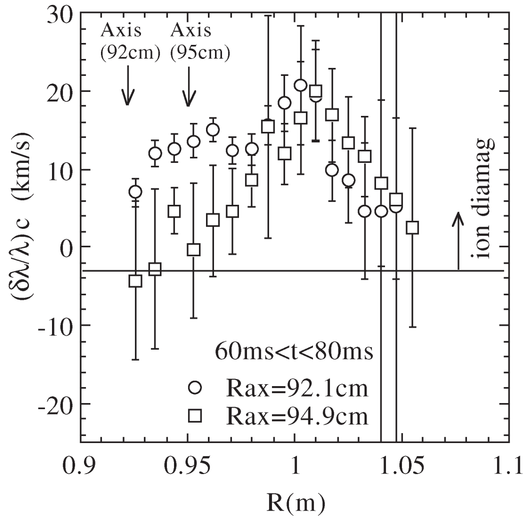

Fig.1 Doppler shift of CVI spectral line (λ=529nm) observed in the N-ITB plasmas by a vertical viewing at a vertical elongated section.

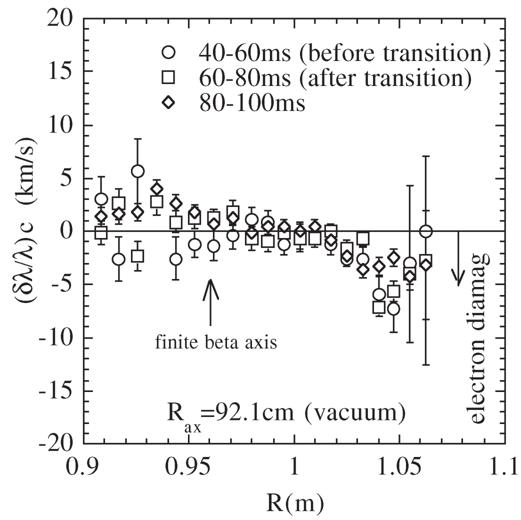

Fig.2 Poloidal rotation in an ETB plasma. The diagnostic method is identical to that in the cases of Fig.1

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